PATENT SPECIFICATION

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(19)

(54) BISTABLE, ELECTROMAGNETICALLY-ACTUATED VALVE

(71) We, FLUID DEVICES LIMITED, a British company, of 16 Brook Gardens, Coombe Lane West, Kingston-upon-Thames, Surrey, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a bistable, electromagnetically actuated valve (which may be referred to as a solenoid valve) especially (but not necessarily solely) of a pulse-operated type, comprising a moving armature, at least one stationary winding for electrical energisation and moving the armature, and a stationary annular permanent magnet for influencing the movement or positioning of the armature, especially (but not necessarily) for magnetically latching the armature, that is to say, for causing the armature to be positively retained in the end position it has reached until such time as the valve is actuated to move the armature to the other end position, this latching enabling the valve to be actuated by a current pulse without requiring continuous energisation to retain the armature in its proper position.

In British Patent Specification No. (Application No. 50624/72) (Serial No. 1,419,262), there is described and claimed an electromagnetic actuator comprising a moving armature, at least one stationary winding for electrical energisation and moving the armature, and a stationary composite annular permanent magnet which influences the movement or positioning of the armature, the composite magnet being formed of at least two individual permanent magnets which are magnetised so as to have the pole face radially inwards of the other pole face, the individual magnets being separated along generally radial planes.

According to the invention there is provided a bistable electromagnetically-actuated valve comprising;

a moving armature, movable in an enclosed space between two end positions;

at least one stationary winding for electrical energisation and moving the armature;

a stationary annular permanent magnet which influences the movement or positioning of the armature;

a valve orifice at one end of the enclosed space in which the armature moves, the valve orifice being in communication with a first pressure fluid connection;

a valve seat on the armature itself, for closing the valve orifice; and

a second pressure fluid connection in communication with the enclosed space in which the armature moves so that when the armature is in one end position, it closes the communication between the first and second pressure fluid connections, and when the armature is in its second end position, communication between the first and second pressure fluid connections is open.

Preferably, the annular permanent magnet extends over the path of movement of the centre of the armature (the armature being movable between the two end positions) and the annular magnet is preferably magnetised so as to have one pole radially inwards of the other pole.

The valve of the present invention may be very simple, and may be particularly suitable for pilot valve use. Although it is preferred that the annular permanent magnet be a composite annular permanent magnet as set forth in British Patent Specification No. 1,419,262 (Application No. 50624/72), referred to above, this need not necessarily be so.

Preferably, said end of the enclosed space has a hole therein, a tube being mounted in the hole and spaced from at least one side thereof to leave a gap outside the tube, and

[*Price 33p*]

the second pressure fluid connection being in communication with the gap, the opening in the end of the tube providing the valve orifice. This feature may provide a particularly simple way of connecting the second pressure fluid connection to the enclosed space and providing a relatively large flow passage which does not occupy too much of the end face or pole-piece area. An alternative arrangement is to have a central bore in the end face to provide the (first) valve orifice and a parallel bore in the end face to connect the enclosed space with the second connection, the latter bore preferably leading into an annular groove in the end face. The, or each valve seat is preferably a rubber valve seat.

The invention will be further described, by way of example, with reference to the accompanying drawings, in which:—

Figure 1 is an elevation of a bistable valve in accordance with the invention; and

Figure 2 is an isometric projection on a larger scale, of the armature in the valve.

A freely slidable armature 1 is enclosed in a tube 6 of diamagnetic material, the latter being attached to stationary pole-pieces 2 and 3 and sealed thereto by O-seals 4.

Surrounding the tube and pole-piece assembly is a steel enclosure formed of an outer sleeve or tubular part 8 and two end pieces 9. Contained therein is a coil bobbin 10 which carries two stationary electrical windings 11*a* and 11*b* contained in separate parts of the bobbin which are nevertheless united as a matter of constructional convenience by four webs or ribs 12. Sandwiched between the two parts of the bobbin and separated and held by the webs 12 are four stationary sector-shaped, ceramic, individual permanent magnets 13 which are magnetised along radial axes, as particularly described in British (Patent Specification No. 1,419,262) (Application 50624/72, referred to above).

An electrical connector 14 carries terminal pins 15 and an earth pin 16, for the purpose of connecting the electrical windings to an external control circuit and providing for electrical safety even when the coil assembly is removed by hand.

The coil assembly is easily removable for exchange or maintenance by unscrewing a retaining nut 17, and is also rotatable to any alternative position around the axis to achieve the most convenient position for the electrical connector 14.

Insulated cavities (not shown) are formed in the connector 14 to provide accommodation for electrical rectifiers, such rectifiers are desirable as integral features where the actuator is to be employed in conjunction with an alternating electrical supply.

Referring to Figure 1, if there is no electrical excitation and the armature 1 is in the upper position shown, the armature 1 is firmly held against the upper pole-piece 2. If the windings 11*a* and 11*b* are suitably energised with direct current, the armature 1 is impelled downwards to the opposite pole-piece 3 and remains firmly held against the lower pole-piece 3 when the electrical excitation is removed. Reversal of the armature 1 can then be accomplished by exciting the windings 11*a* and 11*b* with reverse polarity, and when the excitation is removed, the armature 1 remains in the upper position, firmly held against the upper pole-piece 2. This actuation of the armature 1 is described in detail in British (Patent Specification No. 1,419,262) (Application No. 50624/72), referred to above.

The pole-pieces 2 and 3 are formed with respective valve orifices. Thus the pole-piece 2 has a valve orifice 33 (the second valve orifice referred to above) formed by a bore in a central projection in the pole-piece 2, the bore communicating with a pressure fluid connection 34 (the third pressure fluid connection referred to above). The pole-piece 3 has an axial bore containing a coaxial tube 35. The tube is preferably formed of a ferromagnetic material, but need not be. The lower end portion 36 of the tube 35 is of larger diameter than the remainder, and makes an interfernce fit in the hole in the pole-piece 3, the tube 35 being held in position by any suitable adhesive. The top end of the tube 35 (as seen in Figure 1) forms a valve orifice (the first valve orifice referred to above), and this valve orifice is connected to a pressure fluid connection 37 (the first pressure fluid connection referred to above) by way of the interior of the tube 35 and a transverse bore 38. Around the tube 35, between the tube 35 and the internal wall of the bore in the pole-piece 3, there is an annular duct 39 which communicates with a pressure fluid connection 40 (the second pressure fluid connection referred to above) by way of a transverse bore 41.

The armature 1 has a stepped, central bore containing moulded-in rubber 43 providing a valve seat at each end of the armature 1. As shown in Figure 2, the armature 1 has any suitable number of radial slots 44 in its end faces and longitudinal slots 45 along its peripheral surface, the longitudinal slots intersecting respective radial slots. In this way, good communication is provided between the annular duct 39 and the enclosed space in which the armature 1 moves, which is particularly important when the armature 1 is in its lower end position.

The valve is designed as a two-way pilot valve.

WHAT WE CLAIM IS:—

1. A bistable, electromagnetically-actuated valve comprising:

a moving armature, movable in an enclosed space between two end positions;

at least one stationary winding for electrical energisation and moving the armature;

a stationary annular permanent magnet which influences the movement or positioning of the armature;

a valve orifice at one end of the enclosed space in which the armature moves, the valve orifice being in communication with a first pressure fluid connection;

a valve seat on the armature itself, for closing the valve orifice; and

a second pressure fluid connection in communication with the enclosed space in which the armature moves so that when the armature is in one end position, it closes the communication between the first and second pressure fluid connections, and when the armature is in its second end position, communication between the first and second pressure fluid connection is open.

2. A bistable valve as claimed in claim 1, wherein the second pressure fluid connection is permanently in communication with the enclosed space in which the armature moves.

3. A bistable valve as claimed in either claim 1 or claim 2, wherein said end of the enclosed space has a hole therein, a tube being mounted in the hole and spaced from at least one side thereof to leave a gap outside the tube, and the second pressure fluid connection being in communication with the gap, the opening in the end of the tube providing the valve orifice.

4. A bistable valve as claimed in claim 3, wherein the hole and the tube are coaxial with the enclosed space in which the armature moves, the gap being an annular gap.

5. A bistable valve as claimed in any one of the preceding claims, and having a second valve orifice at the other end of the enclosed space in which the armature moves, a third pressure fluid connection in communication with the second valve orifice, and at least one duct intercommunicating the ends of the enclosed space so that when the armature is in its first end position, the second pressure fluid connection is in communication with the second valve orifice and hence with the third pressure fluid connection.

6. A bistable valve as claimed in claim 5, wherein said duct(s) is or are provided by at least one radial slot in at least one of the end faces of the armature and at least one longitudinal slot along the peripheral surface of the armature, the longitudinal slot(s) intersecting the (respective) radial slot(s).

7. A bistable valve, substantially as herein described with reference to, and as shown in, the accompanying drawing.

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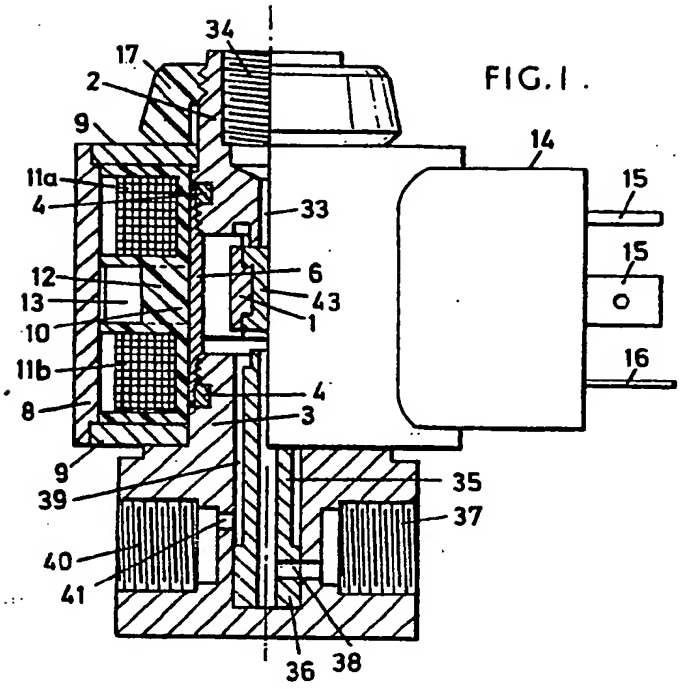

FIG. 1.

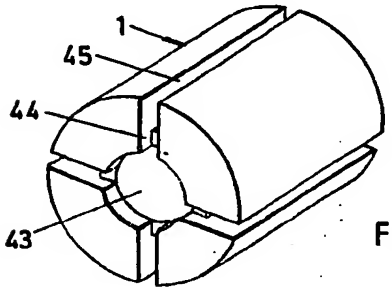

FIG. 2.